

DESCRIPTION

Piezoelectric Speaker, Speaker System Employing It, and Electronic
Apparatus Employing Piezoelectric Speaker

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TECHNICAL FIELD

The present invention relates to a piezoelectric loudspeaker employing
a piezoelectric material, a loudspeaker system using the loudspeaker, and
an electronic device using the loudspeaker.

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PRIOR ART

A conventional piezoelectric loudspeaker employing a piezoelectric
material disclosed in Japanese Laid-Open Publication No.11-164396
includes a single diaphragm and a single piezoelectric material provided at
the diaphragm.

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Since having the single diaphragm and piezoelectric material, the
conventional piezoelectric loudspeaker has difficulty in reproducing of a
sound in wide frequency range. Specifically, this loudspeaker having the
piezoelectric material vibrating by deforming causes the piezoelectric
material to have a high Q factor, hence having a narrow reproducing
frequency range.

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SUMMARY OF THE INVENTION

A piezoelectric loudspeaker includes: a diaphragm; a first piezoelectric
material provided in a first area of the diaphragm; and a second
piezoelectric material provided in a second area of the diaphragm different
from the first area. The second area has a sound reproduction band

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different from that of the first area. This piezoelectric loudspeaker has a wide reproduction frequency range.

BRIEF DESCRIPTION OF THE DRAWINGS

5 FIG. 1 is a perspective view of a loudspeaker box according to an exemplary embodiment of the present invention.

FIG. 2 is a perspective view of a tweeter according to the embodiment.

FIG. 3 shows a sound pressure frequency characteristic of the tweeter according to the embodiment.

10 FIG. 4 is a cross-sectional view of the tweeter shown in FIG. 2 taken at line 4-4.

FIG. 5 is a block diagram of an electronic device according to the embodiment.

15 FIG. 6 is a perspective view of another tweeter box according to the embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 is a perspective view of a loudspeaker system according to an exemplary embodiment of the present invention. A front face of
20 loudspeaker box 1 having a rectangular shape has tweeter 2, squawker 3, woofer 4, and bass-reflex port 5 provided from the upper direction to the lower direction. Tweeter 2 has a sound reproduction frequency range, such as 5kHz to 100kHz. Squawker 3 has a sound reproduction frequency range from 500Hz to 5kHz. Woofer 4 has a sound reproduction frequency range
25 from 20Hz to 500Hz. Bass-reflex port 5 emphasizes a portion lower than 100Hz in the reproduction range of woofer 4.

FIG. 2 is a perspective view of tweeter 2 according to the embodiment.

FIG. 3 shows a sound pressure frequency characteristic of tweeter 2. Tweeter 2 includes tweeter box 6 and a single diaphragm 7 exposed at the front face of the tweeter. As shown in FIG. 2, diaphragm 7 includes plural areas 8, plural areas 9 smaller than areas 8, and plural areas 10 smaller than areas 9. As shown in FIG. 3, area 8 has characteristic 108 having a sound reproduction frequency range from 5kHz to 80kHz. Area 9 has characteristic 109 having a sound reproduction frequency range from 10kHz to 100kHz. Area 10 has characteristic 110 having a sound reproduction frequency range from 40kHz to 100kHz. Areas 8, 9, and 10 compose tweeter 2 having characteristic 102 of a range from 5kHz to 100kHz as the combination of the sound frequency ranges.

FIG. 4 is a cross-sectional view of diaphragm 7 of tweeter 2 shown in FIG. 2 taken at line 4-4. Areas 8 to 10 are provided on diaphragm 7. Diaphragm 7 is made of SiO_2 and has a thickness of 30000Å. A back face of diaphragm 7 has base 11 that is made of Si and has a thickness of 500µm. Base 11, a frame body provided around openings 8a to 10a, has openings 8a to 10a corresponding to areas 8 to 10, respectively (opening 8a is not shown). Openings 8a to 10a have respective areas corresponding to areas 8 to 10 so that opening 9a is smaller than opening 8a while opening 10a is smaller than opening 9a. The base as the frame body provides areas 8 to 10 with sound reproduction frequency ranges different from each other easily.

Diaphragm 7 has lower electrodes 12 made of platinum thereon. Lower electrodes 12 corresponding to openings 8a to 10a has thereon piezoelectric thin film 14 via buffer layer 13. Piezoelectric thin film 14 is ceramic of mixture of lead titanate and lead zirconate consisting of PZT. Lower electrodes 12 around piezoelectric thin films 14 have thereon insulating films 15 made of resin on which upper electrodes 16 are provided,

respectively. Piezoelectric thin films 14 may be provided on diaphragm 7 at once by a piezoelectric-thin-film-forming process.

FIG. 5 is a block diagram of an electronic device according to the embodiment. As shown in FIG. 5, piezoelectric thin films 14 corresponding to areas 8 to 10, respectively, are fed with sound source signals via upper electrodes 16. Sound source 17 is connected with amplifier 18 and amplifier 18 is connected to piezoelectric thin films 14 of areas 8 to 10 in parallel to each other. Piezoelectric thin films 14 of areas 8 to 10 and amplifier 18 have protection circuits 19a to 19c for preventing over-currents between thin films and the amplifier. Phase controllers 20a to 20c control phases of signals applied to areas 8 to 10, respectively. Gain adjustment circuits 21a to 21c adjust the amplitudes of signals applied to areas 8 to 10, respectively. This structure provides tweeter 2 with a flat sound pressure frequency characteristic shown in characteristic 102 of FIG. 3 in a wide and high frequency range from 5kHz to 100kHz.

Sounds in a nature include frequency components higher than 20kHz, which human beings cannot hear. For example, a musical instrument, such as a cymbal, emits a sound having a component higher than 20kHz. Human beings hear a sound from 20Hz to 20kHz out of a combination and interference of such sounds having such high frequency components.

Therefore, tweeter 2 of the embodiment reproducing a sound from 5kHz to 100kHz can reproduce sounds more naturally. Thus, it is recently said that sound source 17, such as an audio device, needs to output a signal having a frequency up to 100kHz.

FIG. 6 shows another tweeter 602 according to the embodiment. Tweeter 602 is of a so-called add-on-type for emphasizing a treble added to an existing electronic device. Tweeter 602 includes therein protection

circuits 19a to 19c, phase controllers 20a to 20c, and gain adjustment circuits 21a to 21c shown in FIG. 5 and has at the back face side a connection terminal for the connection to amplifier 18.

5 Tweeter 2 as a piezoelectric loudspeaker according to the embodiment has areas 8 to 10 having sizes different from each other. The number of the areas different from each other is not limited to three and thus may be two or more, hence providing the same effects as those of the loudspeaker according to the embodiment.

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INDUSTRIAL APPLICABILITY

As described above, the piezoelectric loudspeaker according to the present invention has a wide reproduction frequency range.